International Journal of Environment, Agriculture and Biotechnology
Vol-7, Issue-4; Jul-Aug, 2022

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Peer Reviewed

Effect of spraying salicylic acid and biostimulant (Biomagic) on productivity and quality of pomegranate under heat stress in Siwa Oasis

Amin M. G. E. Shaddad[1], Sheren A. Abd El-Hamied[1,2,*]

[1]Pomolgy Unit, Plant Productions Department, Desert Research Center, Cairo 11753, Egypt
[2]Regional Development Centers (RDC), Academy of Scientific Research and Technology (ASRT), Head of the project

Received: 05 Jul 2022; Received in revised form: 25 Jul 2022; Accepted: 02 Aug 2022; Available online: 08 Aug 2022

Abstract**—** *This study was implemented through the project (Sustainable development of fruit trees affected by some environmental stress in Matrouh governorate) funded by Regional Development Centers (RDC), Academy of Scientific Research and Technology (ASRT) (Call no. 2/2019/ASRT-RDC). It was carried out on 81 trees of Manfalouty pomegranate cv (Punica granatum) during the two successive seasons of 2020 and 2021 at the Khamisa research station of D.R.C. at Siwa Oasis-Matrouh Governorate-Egypt. The study aimed to investigate the influence of salicylic acid (SA) and the biostimulant biomagic to improve fruit productivity and the quality of pomegranate var. "Manfalouty." All the treatments were subjected to the same agricultural practice. The foliar treatments were used, tap water (T_1), salicylic acid 100 ppm (T_2), salicylic acid 200 ppm (T_3), biomagic at 7.5 cm/l (T_4), biomagic at 8.5 cm/l (T_5), salicylic acid 100 ppm + biomagic 7.5 cm/l (T_6), salicylic acid 100 ppm + biomagic 8.5cm/l (T_7), salicylic acid 200 ppm. The obtained results showed that all the treatments were affected by spraying fruit trees with salicylic acid in combination with biomagic, followed by the solo concentrations of each treatment in both seasons. Meanwhile, T_9 gave the best vegetative growth, fruit physical, chemical properties, and gave the lowest total acidity, fruit cracking percentage, and sunburn percentage in the 1st and 2nd season, respectively.*

Keywords**—** ***pomegranate, Biomagic, salicylic acid, heat stress, Siwa Oasis.***

I. INTRODUCTION

The pomegranate, (*Punica granatum*) L., is a member of the Punicaceae plant family and is primarily found in semi-arid, mild-temperate, and subtropical regions. Today, pomegranate orchards are planted all over the world, but they are most popular in the Mediterranean Basin, where the fruits are of the highest quality **[Stover and Mercure, 2007; Holland et al., 2009].** One of the most significant pomegranate cultivars growing successfully in Egypt is known as Manfalouty. However, there are numerous issues with pomegranate production during the development of the trees and fruit production. Low fruit quality and cracking during maturity are the most typical issues **(Abd El-all and Fouad, 2019).**

The Siwa Oasis is located in the northern part of the Western Desert of Egypt, at the GPS (Global Positioning System) of 29.12_N latitude and 25.29_E longitude, with an elevation of 18 meters below sea level and 315 kilometers from the Mediterranean coast. It is characterized by very hot and dry climate conditions, especially during summer, and the main activity of Siwean people is agriculture, which depends on groundwater. Because that oasis is a desert closed area and has an irregular climate, and consequently heat stress during the summer season (temperatures can amount to 45 °C), almost all fruit productivity is negatively affected.

One of the most dangerous abiotic variables, heat stress reduces production and quality, which causes significant economic losses. The morphological,

anatomical, physiological, and biochemical alterations in the plant system are impacted by high temperatures. Due to inadequate understanding of heat stress at crucial periods for fruit crops, success in managing heat stress is restricted. **Garcia et al. (2020** (2020). A pomegranate crop may suffer from heat stress and sunburn as a result of high temperatures and ultraviolet (UV) light, severely lowering the crop's commercial yield and eroding growers' profits.

The use of conventional chemicals, which have negative effects on people, animals, and the environment, is a common method used to improve the fruit quality in pomegranates. Unusual methods to improve pomegranate fruit quality are now urgently required to address the issues caused by people's careless usage of chemicals. Natural substances like salicylic acid (SA) are signaling molecules that are crucial for controlling plant growth and strengthening plants against biotic and abiotic stresses **(Hayat et al., 2010; War et al., 2012).** They also influence the quality of fruits by improving plant strength under biotic and abiotic stresses **(Kondo, 2006; Elwan and El-Hamahmy, 2009; Marzouk and Kassem, 2011)**. These natural compounds are produced in the plant in low quantities that might not boost the plant to overcome the biotic and abiotic stress. For this reason, the exogenous applications of these compounds enhance plant activity **(Abd El-all and Fouad, 2019).**

Salicylic acid participates in the regulation of numerous physiological processes in plants, including stomatal closure, photosynthesis, ion uptake, inhibition of ethylene biosynthesis, transpiration, and stress tolerance **(Khan et al., 2003; Simaei et al., 2012).** Salicylic acid is an endogenous growth regulator of phenolic nature and acts as a potential non-enzymatic antioxidant. It promotes flowering, lengthens the life of flowers, delays senescence, and speeds up cell metabolism **(Bhupinder and Usha, 2003).** Plant development can be controlled by it **(Amanullah et al., 2010).**

SA application influences a wide variety of plant processes and induces antioxidant synthesis **(Yordanova and Popova, 2007)**. It is a key signal molecule for the expression of multiple modes of plant stress resistance such as salinity and drought **(Chini et al., 2004)**, chilling **(Kang and Saltveit, 2002)**, heavy metal tolerance **(Freeman et al., 2005),** heat **(Larkindale et al., 2005)**, and osmotic stress (**Borsani et al., 2001**). Salicylic acid plays a crucial role in the regulation of physiological and biochemical processes during the plant life cycle, by affecting a natural series of changes, such as growth, flowering, fruit ripening, and others (**Rivas and Plasencia, 2011; Koo et al., 2020**). In addition, **Stuart et al., (2022)** said endogenous levels of SA, which are often associated with biotic and abiotic stress responses, negatively affect pollen LTMH (tolerance (Long-Term Mild Heat Tolerance). We found that reducing SA levels had distinct effects on anther and pollen physiology under LTMH, and found evidence for a role of JA signaling in the mechanism behind pollen thermo tolerance of the low-SA line. Sprayings salicylic induced a range of beneficial effects such as improvement in bioactive compounds, sugars, fruit size, and organic acids in fruit trees species such as apples **(Shaaban et al., 2011; Giannousis, 2012)**, pears **(Cao et al., 2006**), sweet cherries (**Yao and Tian, 2005; Giménez et al., 2014, 2017; Valverde et al., 2015),** oranges **Huang ett al., 2008),** grapes **(Champa et al., 2015; Oraei et al., 2019; García et al., 2020b)**, and plums **(Martínez et al., 2017, 2018)**

Bio-fertilization is the biological preparation containing primarily patented strains of micro-organisms in sufficient numbers. Bio-fertilizers are proven to sometimes eliminate the use of pesticides and rebalance the ratio of plant nutrients in soils. Bio-fertilizers are very safe for humans, animals, and the environment. Since they reduce the great pollution that happens in the environment. (**Sheren, 2019).** They are easy and safe to handle with field applications that improve their efficiency in increasing crop yields and decreasing the costs of some agricultural practices. It is worthwhile to state that, biofertilizers do not replace mineral fertilizers, but significantly reduce their rate of application (**Saber, 1993**). They are the most important for plant production and soil as they play an important role in increasing vegetative growth, yield, and fruit quality (Soliman,**2001**) in guava and banana plants; and **(Osman et al., 2010)** in olive plants, (**Chokha et al., 2000; El-Geuoshy, 2011 and Bakry et al., 2013)** on sweet orange. In addition, **Shaban and Mohsen (2009)** showed that all bio-fertilizers were effective in improving the vegetative growth and nutritional status of sweet orange transplants. **Khamis**, **et al**., **(2014)** indicated that leaf photosynthetic pigment content (chlorophyll A, B, and carotenoids) was improved by bio-fertilizers.

Biomagic product is a biological promoter of microbial origin and contains many biological products that affect plant growth. This product consists of amino acids. (Amino acids are basic ingredients in the process of protein synthesis. Plants require amino acids for overall plant growth and development), vitamins (Vitamins are essential for plant growth; they assist plants in growing by providing essential nutrients), and macro and microelements (Micronutrients are involved in all metabolic and cellular functions (Suman et al., 2017). This, in turn, increases the vegetative growth, and period of production, enhancing photosynthesis and encouraging

the absorption of water and nutrients from the soil, (El-Sibaie,1995)). **Chokha et al., (2000)** stated that Volkamryana lemon and Mosambi sweet orange increased growth measurements using biomagic.

Therefore, The current study's goal is to investigate how the biostimulant biomagic and salicylic acid (SA) affect the productivity and quality of pomegranate var. "Manfalouty" fruit.

II. MATERIAL AND METHODS

This study was implemented through the project (Sustainable development of fruit trees affected by some environmental stress in Matrouh Governorate) funded by Regional Development Centers (RDC), Academy of Scientific Research and Technology (ASRT) (Call no. 2/2019/ASRT-RDC). It was conducted during the two successive seasons of 2020 and 2021 at khamisa research station of D.R.C. at Siwa Oasis – Matrouh Governorate – Egypt on 81 trees of Manfalouty pomegranate cv (*Punica granatum*) grown under saline and heat stress to study the effect of some biological compounds (biomagic and salicylic acid) on improving quality and productivity. The selected trees were 15 years old, planted at 3X 5 m grown in sandy soil under a drip irrigation system. All are almost uniform in shape and received the common horticultural practices. Physical and chemical analysis of the experimental soil is shown in Table 1, meanwhile, the chemical analysis of used water from irrigation is recorded in (Table 2). Nine treatments of foliar applications, tap water (T_1), salicylic acid 100 ppm (T_2), salicylic acid 200 ppm (T_3), biomagic at 7.5cm/l (T_4), biomagic at 8.5cm/l(T_5): salicylic acid 100 ppm +biomagic 7.5cm/l (T_6), salicylic acid 100 ppm + biomagic 8.5 cm/l (T_7), salicylic acid 200 ppm +biomagic 7.5cm/l (T_8) and salicylic acid 200 ppm +biomagic 8.5 cm/l (T_9) sprayed once every two months starting from January until the harvest time. The experiment was designed as a complete block randomized design each treatment represented by 3 replicates of 2 trees each. The analysis of the biomagic is shown in table 3. **El Massiry, (2009)**

Table 1: Some physical and chemical analyses of the experiment soil and irrigation water at khamisa research station Siwa oasis.

Particle size distribution%		**Sand**	**Silt**	**Clay**	**Some chemical analysis of irrigation water**
		81.2	8.57	10.23	
Texture soil		Sand loamy			
Ec ds/m1		9.05			6.78
pH		7.7			7.7
Units		**meq/l**			
Soluble captions	**Ca^{++}**	25			21.8
	Mg^{++}	12.1			9.7
	Na^{+}	52.1			35.95
	K^{+}	1.3			0.35
Soluble anions	**CO_3^{--}**	0.0			0.00
	HCO_3^{-}	2.8			9.5
	SO^{--}_4	26.2			10.8
	Cl^{-}	61.5			47.5

Table 2: Some chemical analysis of the experiment irrigation water at khamisa research station Siwa oasis.

Biomagic			
Amino acids (2.07%)	**Vitamins (0.04 %)**	**Ma.E (in mg/l)**	**M i. E (3.7 % in mg/l)**
Arginine	**thiamine**	**1125 N**	**45 Mg**
cysteine	**Biotene**	**550 P2 O5**	**160 Fe**
glycine	**choline**	**625 k2O**	**124 Zn**
histidine	**folic acid**		**100 Mn**
leucine	**niacin**		**45 Cu**
lysine	**pantothenic**		**14 B**
phenylalanine	**pyridoxine**		**12 Mo**

threonine	**riboflavin**		**8 Co**
tryptophan			
tyrosine			
valine			

Table 3: The analysis of biomagic

Biomagic			
Amino acids(2.07%)	**Vitamins(0.04 %)**	**Ma.E(in mg/l)**	**M i. E(3.7 % in mg/l)**
Arginine	thiamine	1125 N	45 Mg
cysteine	Biotene	550 P2 O5	160 Fe
glycine	choline	625 k2O	124 Zn
histidine	folic acid		100 Mn
leucine	niacin		45 Cu
lysine	pantothenic		14 B
phenylalanine	pyridoxine		12 Mo
threonine	riboflavin		8 Co
tryptophan			
tyrosine			
valine			

The following parameters were measured:

1. **Shoot length and Leaves number /shoot:** at the end of each current season (first week of October).
2. **Leaf area (cm^2):** was determined by using the leaf area meter CL203.
3. **Total chlorophyll contents in leaf:** measured using Minolta chlorophyll meter SPAD- 502 was estimated on the selected branches
4. **Yield per tree:** At harvest time, the number of fruits per each treated tree was counted and reported then the yield (kg) per tree was weighed and recorded.
5. **Fruit parameters (fruit physical characteristics)**: Fruits samples were taken at the harvest time to be used for determining the physical properties (i.e., fruit weight (g), fruit height (cm) , and fruit diameter (cm).

   Fruit quality (fruit chemical characteristics): a sample of 10 mature fruits of each tree was taken at the harvest time to be used for determining the chemical properties (i.e., the total soluble solids percentage (T.S.S. %) that were measured using a hand refractometer, and the fruit juice % used to determine total acidity by titration against standard sodium hydroxide solution (0.1 N) using phenolphthalein as an indicator). Total sugars and vitamin C content were determined according to **A.O.A.C (1985)**.

6. **Statistical Analysis**

   The obtained data were subjected to analysis of variance according to **Clarke and Kempson (1997).** Means were differentiated using the Range test at the 0.05 level **(Duncan, 1955).**

III. RESULTS AND DISCUSSIONS

Shoot length (cm), leaves number /shoot

Data in table (4), clear that shoot length and leaves number were significantly affected by all treatments in both seasons. However, T_9 gave the best shoot length and leaves number in both seasons. On the other side, T_1 was the lowest in shoot length and leaves number in both seasons

Table.4: Effect of spraying salicylic acid (SA) and biomagic (BM) on shoot length and number of leaves of "Manfalouty" pomegranate trees during 2020 and 2021seasons.

Parameters / Treatments	Shoot length (cm)		Number of leaves (cm)	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	17.19h	18.01h	17.13i	17.58i
T_2	20.56g	20.83g	18.39h	19.54h
T_3	22.19f	22.52f	20.11g	20.93g
T_4	24.17e	23.72e	22.71f	21.82f
T_5	24.75e	24.77d	24.55e	22.32e
T_6	24.63d	25.09d	25.59d	23.96d
T_7	26.80c	26.80c	27.39c	26.12c
T_8	28.66b	28.80b	28.45b	28.79b
T_9	31.44a	30.17a	30.23a	29.87a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Leaf area (cm^2) and leaf total chlorophyll (SPAD)

It could be noticed from tables (5) that all treatments were significantly affected in leaf area and leaf total chlorophyll in both seasons. However, T_9 gave the best leaf area (5.96 cm^2 and 6.13 cm^2) and leaf total chlorophyll (58.43 and 60.92) in both seasons respectively. On the contrary, untreated trees (control) were the lowest leaf area (2.56 cm^2 and 2.25 cm^2) and leaf total chlorophyll (36.22 and 37.95) in both seasons.

The positive effect of salicylic acid on growth may be due to its effect on plant hormones **(Shakirova, 2007)** salicylic acid increased leaf chlorophyll content (**Abdel Aziz et al., 2017)**. Additionally, it can influence stomatal movement, photosynthesis, ethylene production, plant water relations, and the ability of ABA to reverse the effects of leaf abscission **(Arfan et al., 2007)**. **Abd El-Naby et al., (2020)** spraying SA at a high concentration shows a positive effect on vegetative growth characteristics of the navel orange. **Mokhtar et al (2011)** observed varying concentrations of SA (50 to 400 ppm) and frequencies (1, 2, 3, or 4 times) with a gradual promotion in the leaf area. **Hamdy et al (2019)** Spraying SA at 50 to 200 ppm improved all vegetative growth aspects, leaf chlorophyll contents on fig trees. **Ahmed et al (2015)** Using salicylic acid at 50 to 200 ppm enhanced shoot length, leaf area, and total chlorophylls on mango. These lead to more carbohydrate production and this is reflected in fruit quality.

The obtained results regarding the effect of salicylic acid on fruit quality go in line with the findings of **(Abdel Aziz et al. 2017** and **Amro et al 2020)** on pomegranate fruits.

It is also could be due to the biomagic contents of proteins, amino acids, vitamins, and hormones, as well as some micronutrients, growth regulators, and vitamins which enhanced cell division, metabolism, and other biological reactions, in addition to the activation effect of these components on photosynthesis and promoting protoplasm formation including RNA and DNA that important for cell division, All of these materials lead to reducing the impact of stress on the plant **(Khedr and Farid 2000, El Massiry 2009, Ibrahim 2009, El-Hifny and El-Sayed 2011and Hanan 2016).**

These results are in harmony with those obtained by **(Khedr and Farid 2000, Amer 2004, El Massiry 2009, and Ibrahim 2009)** who reported that biomagic improved growth. In addition, **Sheren (2014a&b)** stated that the addition of bio-fertilizers increased vegetative growth measurements of mango.

Table.5: Effect of spraying salicylic acid (SA) and biomagic (BM) on leaf area and leaf chlorophyll content of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Leaf area cm^2		leaf total chlorophyll (SPAD)	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	2.56i	2.25i	36.22i	37.95i
T_2	2.47h	2.61h	38.57h	40.01h
T_3	3.06g	2.97g	41.53g	42.36g
T_4	3.54f	3.35f	44.49f	44.01f
T_5	3.93e	3.83e	47.87e	48.15e
T_6	4.37d	4.29d	50.16d	49.71d
T_7	4.57c	4.93c	53.51c	54.43c
T_8	5.28b	5.6b	56.61b	57.31b
T_9	5.96a	6.13a	58.43a	60.92a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Fruit length (cm), fruit diameter (cm), and fruit weight (g)

Data in the table (6), clear that fruit length, fruit diameter, and fruit weight were significantly affected by all treatments in both seasons. However, T_9 gave the highest fruit length, fruit diameter, and fruit weight in the 1st the 2nd seasons. On the other hand, the untreated trees T_1 gave the lowest fruit length, fruit diameter, and fruit weight in both seasons.

Table.6.:Effect of spraying salicylic acid (SA) and biomagic (BM) on fruit length and fruit diameter of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Fruit length (cm)		Fruit diameter (cm)		fruit weight(g)	
	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2021
T_1	7.51 e	7.57 e	7.40 f	7.52 g	349.22 g	351.84 g
T_2	7.61 de	7.69 d	7.58 f	7.73 f	355.88 f	357.29 f
T_3	7.73 cde	7.77 cd	7.89 e	7.92 e	362.12 e	364.44 e
T_4	7.75 bcd	7.79 cd	7.94 de	8.02 e	367.61 d	368.07 e
T_5	7.79 abc	7.83 c	8.10 d	8.20 d	373.14 c	375.45 d
T_6	7.81 ab	7.88 c	8.32 c	8.48 c	376.67 b	377.45 cd
T_7	7.89 ab	8.02 b	8.54 b	8.67 b	379.33 a	381.54 bc
T_8	7.92 a	8.13 b	8.76 a	8.72 b	380.15 a	385.05 b
T_9	7.94 a	8.33 a	8.80 a	8.96 a	380.99 a	400.11 a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Fruit grains weight (g) and grains/fruit weight percentage

Concerning the results in Table 7, fruit grains weight (g), and grains/fruit weight % were significantly affected by all treatments in both seasons. However, T_9 gave the best fruit grains weight (g) (303.13 and 311.33 (g) and grains/fruit weight percentage (79.56 and 77.81 in 1st and 2nd season respectively. On the other side, T_1 (sprayed with tap water) gave the lowest fruit grains weight (g) and grains/fruit weight percentage in both seasons.

Table.7: Effect of spraying salicylic acid (SA) and biomagic (BM) on fruit grains weight, grains/fruit weight of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Fruit grains weight (g)		Grains/fruit weight %	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	219.44 i	221.81 h	62.84 i	63.04 i
T_2	227.78 h	231.26 g	64.00 h	64.73 h
T_3	238.25 g	246.42 f	65.79 g	67.62 g
T_4	256.77 f	259.59 e	69.85 f	70.53 f
T_5	264.11 e	268.37 d	70.78 e	71.48e
T_6	276.46 d	280.67 c	73.40 d	74.36d
T_7	285.33 c	289.11 b	75.22 c	75.77c
T_8	291.48 b	295.83 b	76.67 b	76.83b
T_9	303.13 a	311.33 a	79.56 a	77.81a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Number of fruits/tree and total yield/tree (Kg)

It is shown from the data in the table (8) that the number of fruits and total yield/tree were significantly affected by all treatments in both seasons. In addition, T_9 gave the best number of fruits and the total yield in both seasons respectively. On the other hand, T_1 trees gave the lowest number of fruit trees and total yield in both seasons.

The number of fruits/trees and total yield/tree (Kg) were affected significantly by spraying trees with salicylic acid in combination with biomagic in both seasons. It is observed that spraying the solo concentrations of salicylic acid and biomagic recorded less number of fruit /tree and total yield/tree (kg) in the 1st and the 2nd season respectively.

The increase in fruit number by salicylate treatments could be due to: an increased flowering rate, set fruits, or a decrease in fruit abscission. An increase in plum tree yield has been recently reported as a consequence of salicylate treatments, although it was due to increased fruit mass but not fruit number. **(Martínez et al., 2018).** SA activates growth and the nutritional state of trees due to an increase in fresh and dry weight and chlorophyll, carotenoid, and sugar concentration in leaves, which illustrates an enhancement of net photosynthesis on trees **(Helaly et al., 2018**). The positive effect of SA on yield may be due to its effect on plant hormones (**Shakirova, 2007). Hamdy et al., (2019**) found that different concentrations of SA represented varying effects on the yield of fig tree.

These results were in agreement with **Amro et al., (2020)** found that salicylic treatments enhanced the yield of pomegranate var "wonderful". **Mokhtar et al (2011)** sprayed Anna apple trees with salicylic acid at 200 ppm three times (at growth start, just after fruit set, and at 14 days later) giving an economical yield. In addition, using salicylic acid was very effective to improve the yield of fruits (**Ahmed and Abd El-Hameed, 2004; Ibrahim-Asmaa, 2006; Imran et al., 2007, Abd El-Kariem, 2008 and Ahmed et al., 2010). Abd El-all and Fouad (2019**) SA improved yield (kg/tree), fruit weight (g), and fruit number/tree. **Ying et al., (2014**) revealed that the applications of SA decreased the flower dropping percentage and increased the fruit setting percentage on citrus. **Ahmed et al (2015)** said that Sukkary mango trees'

yield was increased by two sprays of salicylic acid at 100 ppm at the beginning of growth and after fruit set. **Helaly et al., (2018**) they found a higher percentage of fruit retention and crop yield on two mango cultivars using SA treatments. In addition, Bio-fertilizers are the most important for plant production they play an important role in increasing yield **(Soliman, 2001**) on guava and banana plants and (**Ahmed et al., 1999 and Osman et al., 2010)** on olive plants, (**Chokha et al., 2000; El-Geuoshy, 2011 and Bakry et al., 2013**) on sweet orange. **Sheren (2019**) proved that biomagic was very effective on yield (fruits number and weights) for the final crop.

Table.8: Effect of spraying salicylic acid (SA) and biomagic (BM) on no of fruits and yield of "Manfalouty`" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	No of fruits		Yield /kg	
	Season 2020	Season 2021	Season 2020	Season 2021
T_1	37.80 f	39.11e	13.21 g	13.76 f
T_2	39.06 ef	39.66 e	13.93 f	14.17 f
T_3	39.21 ef	40.53 de	14.22 f	14.77 e
T_4	40.80 de	41.57 cd	15.00 e	15.30 d
T_5	41.81 cd	42.80 bc	15.62 d	16.07 c
T_6	41.68 cd	44.43 ab	15.74 d	16.77 b
T_7	42.71bc	44.03 ab	16.20 c	16.80 b
T_8	44.19ab	44.59 ab	16.81 b	17.17 b
T_9	45.41a	45.41 a	17.32 a	18.17 a

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200 ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200 ppm + biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Total soluble solid %, total sugars%, vitamin C (mg/100g pulp) and total acidity%

Data in table (9), showed, that total soluble solids, total sugars, vitamin C and total acidity were significantly affected by all treatments in both seasons. However, T_9 gave the highest total soluble solids, total sugars**,** vitamin C and the lowest total acidity. On the other hand, the T_1 treatment gave the lowest total soluble solids, total sugars, vitamin C and the highest total acidity in both seasons.

The obtained results regarding the effect of salicylic acid on fruit quality go in line with the findings of **Abdel Aziz et al., (2017**) on pomegranate fruits. **Hamdy et al., (2019**) The frequency of application of SA from one to three times improved the fruits' physical properties. **Ahmed et al., (2015)** The fruit quality of Sukkary mango trees was improved by two sprays of salicylic acid at 100 ppm at the beginning of growth and after fruit set. In addition**, Amro et al., (2020)** found that salicylic treatments enhanced fruit quality traits of pomegranate "wonderful". Using salicylic acid was very effective in improving the physical characteristics of fruits in different fruit crops (**Ahmed and Abd El-Hameed, 2004; Ibrahim-Asmaa, 2006; Imran et al., 2007, Abd El-Kariem, 2008** and **Ahmed et al., 2010)**. **Mirdehghan, et al., (2012**) The total acidity, TSS, of pomegranates improved by salicylic acid. (**Zhang et al., 2003). Hamdy et al (2019)** A steady and significant increase in T.S.S. percent, a drop in sugars percent, and a decrease in total acidity percent were all produced by increasing the concentration of SA. **Ahmed et al., (2015)** The fruit quality of Sukkary mango trees was improved by two sprays of salicylic acid at 100 ppm at the beginning of growth and after the fruit set. **Abd El-all and Fouad (2019**) SA improved yield (kg/tree), fruit weight (g), fruit number/tree, TSS, acidity %,TSS /acid % ratio. Furthermore, Bio-fertilizers are the most important for plant production and soil as they play an important role in increasing fruit quality (**Soliman,2001**) in guava and banana plants and (**Osman et al., 2010**) in olive plants, **(Chokha et al., 2000; El-Geuoshy, 2011 and Bakry et al., 2013)** on sweet orange. **Sheren (2019)** proved that biomagic was very effective on fruit chemical characteristics of fig.

Table.9: Effect of spraying salicylic acid (SA) and biomagic (BM) on fruit TSS, total sugar, vitamin C and acidity of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	TSS%		Total sugar%		Vitamin C mg/100g pulp		Acidity %	
	Season 2020	Season 2021	Season 2020	Season 2021	Season 2020	Season 2020	Season 2020	Season 2021
T_1	14.12 h	14.28 h	12.10 f	12.40 f	14.41i	14.41i	0.42 a	0.43 a
T_2	14.33 g	14.63 g	12.21 f	12.65 ef	14.74h	14.74h	0.41 ab	0.41 ab
T_3	14.75 f	14.96 f	12.45 e	12.83 e	15.08g	15.08g	0.40 abc	0.38 abc
T_4	15.42 e	15.51 e	12.99 d	13.15 d	15.28f	15.28f	0.39 abc	0.37 bc0
T_5	15.73 d	15.78 d	13.01 d	13.29 d	15.42e	15.42e	0.38 abc	0.37 bc0
T_6	15.97 c	16.17 c	13.58 c	13.77 c	15.62d	15.62d	0.37 abc	0.35 cd
T_7	16.21 b	16.27 bc	14.05 b	14.23 b	15.86c	15.86c	0.36 bc	0.34 cde
T_8	16.35 ab	16.48 b	14.28 a	14.44 b	15.97b	15.97b	0.35 c	0.32 de
T_9	16.49a	16.78 a	14.24 a	14.81 a	16.65a	16.65a	0.35 c	0.30 e

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

Fruit cracking % and fruit sunburned%:

Table 10, cleared that, cracking and sunburn percentage of fruits were significantly affected by all treatments in both seasons. However, T_1 gave the highest cracking and sunburn percentage. On the other hand, the T_9 treatment gave the lowest cracking (14.17 % and 13.7%) and sunburn (9% and 7.87%) in both seasons respectively.

The positive effect of salicylic acid in reducing cracked and sunburned fruits may be attributed to salicylic acid playing a crucial role in keeping cells from ageing and stopping free radicals from oxidizing lipids, which make up the plasma membrane, which may explain why it has a favorable impact on reducing cracked and sunburned fruit. Salicylic acid helps the body's antioxidant system, which also helps with stress management. It is in charge of boosting naturally occurring hormones that are essential for controlling plant growth and development, as well as the production of IAA, and limiting the detrimental effects of various stresses on plant development. **(Senarataa et al, 2004**). Salicylic acid has a significant role in plant water relations, photosynthesis, and growth in plants (**Arfan et al., 2007**). And this is reflected on reducing cracked and sunburned fruits.

The obtained results regarding the effect of salicylic acid on fruit disorders go in line with the findings of **Ahmed et al., (2014)** on pomegranate, **Abdel Aziz et al., (2017**) on pomegranate and **Amro et al., (2020)** on pomegranate.

Table.10: Effect of spraying salicylic acid (SA) and biomagic (BM) on fruit cracking and sunburn of "Manfalouty" pomegranate trees during 2020 and 2021 seasons.

Parameters / Treatments	Cracking%		Sun burn%	
	Season 2020	Season 2021	Season 2020	Season 2021
T1	30.30a	28.46a	18.40a	16.40a

T2	27.30b	26.37b	17.33b	15.37b
T3	25.50c	24.47c	15.63c	14.7c
T4	24.43c	23.23d	14.53d	13.20d
T5	22.47d	21.57e	13.43e	12.4e
T6	20.40e	19.63f	12.53f	11.37f
T7	18.60f	22.80g	11.00g	10.60g
T8	16.67g	17.477h	10.33h	9.30h
T9	14.17h	13.7i	9.00i	7.87i

Means having the same letter (s) in each column is not significantly different at 5% level.

(T_1): tap water:, (T_2): salicylic acid 100 ppm, (T_3): salicylic acid 200ppm, (T_4): biomagic at 7.5%, (T_5): biomagic at 8.5%: (T_6): salicylic acid 100 ppm+ biomagic 7.5cm/l, (T_7): salicylic acid 100 ppm+ biomagic 8.5cm/l, (T_8): salicylic acid 200ppm+biomagic 7.5cm/l and (T_9): salicylic acid 200ppm+biomagic 8.5cm/l

IV. CONCLUSION

It could be concluded that spraying pomegranate with salicylic acid 200 ppm + biomagic 8.5cm/l gave the best vegetative growth, fruit physical, chemical properties, and gave the lowest total acidity, fruit cracking percentage, and sunburn percentage under heat stress in Siwa oasis.

ACKNOWLEDGEMENTS

The head of the project would like to thank Prof. Mahmoud Sakr for his support. Also all the project team extend their gratitude to the Academy of Scientific Research and Technology (ASRT), and Desert Research Center (DRC), Egypt for providing the opportunity to pursue studies. This work was supported (funded) by Regional Development Centers (RDC), Academy of Scientific Research and Technology (ASRT).

REFERENCES

[1] **A.O.A.C. (1985).** In "Official Methods of Analysis". Association of Official Agricultural Chemists, 14th Ed.: Benjamin Franklin Station Washington, DC, USA, p. 490-510.

[2] **Abd El-all, E. H. and H. A. Fouad (2019).** Foliar Application of Gebbrillic and Salicylic Acids Improves Fruit Quality and Yield and Reduces Aphid Population in Pomegranate (*Punica granatum* L.) *J. Plant Production, Mansoura Univ., Vol. 10 (3): 247 - 252, 2019*

[3] **Abd El-Kariem, A.M., (2008).** Relation of growth and fruiting in Crimson seedless grapevines to spraying some antioxidants. M.Sc. Thesis., Fac. of Agric. Minia Univ. Egypt.

[4] **Abd El-Naby S.K.M., A. Abdelkhalek*, M.H.M. Baiea and O.A. Amin (2020).** mitigation of heat stress effects on washington navel orange by using melatonin, gibberellin and salicylic treatments *Plant Archives*Vol. 20 Supplement 1, pp. 3523-3534

[5] **Abdel Aziz, F.H., El-Sayed, M.A. and Aly, H.A., (2017)**. Response of Manfalouty pomegranate trees to foliar application of salicylic acid. Assiut J. Agric. Sci., 48(2):59-74

[6] **Ahmed F.F., Mansour A.E.M. and Merwad M.A. (2015)**. Physiological Studies on the Effect of Spraying Salicylic Acid on Fruiting of Sukkary Mango Trees Int.J. ChemTech Res.,8(4),pp 2142-2149

[7] **Ahmed, F.F. and H.M. Abd El-Hameed, (2004)**. Influence of some antioxidants on growth, vine nutritional status, yield and quality of berries in Banaty grapevines. Assiut J. Agric. Sci., 34(4): 131-139.

[8] **Ahmed, F.F., Mohamed, M.M., Abou El- Khashab, A.M.A. and Aeed, S.H.A.,(2014)**. Controlling fruit splitting and improving productivity of Manfalouty pomegranate trees by using salicylic acid and some nutrients. World Rural Observations 6(1):87-93

[9] **Ahmed, F.F., F.H. Abd El-Aziz and A.M. Abd El-Kariem, (2010)**. Relation of fruiting in Crimson seedless grapevines to spraying some antioxidants. 2nd Conf. Agric. Environ. Sci. "Agriculture and DevelopmentScopes". Fac. Agric., Minia University, Minia, Egypt. 22-24 March. pp: 103-112

[10] **Amer, S.S.A., (2004**). Growth, green pods yield and seeds yield of common bean (phaseolus vulgarisL.) affected by active dry yeast, salicylic acid and their interaction. J. Agric. Sci. Mansoura Univ., 29: 1407-1422

[11] **Amanullah M.M., S. Sekar and S. Vincent (2010**). Plant growth substances in crop production. *Asian J. Plant Sci.*, **9:**215–222.

[12] **Amro S.M. Salama, Osama H.M. El Gammal and Amin M. G. E. Shaddad (2020)**. Effect of salicylic and ascorbic acids on yield and fruit quality of wonderful pomegranate trees *Int. J. Adv. Res. 8(09), 1059-1068*

[13] **Arfan, M., Athar, H.R. and Ashraf, M., 2007**. Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt

stress? J. Plan. Physiol. 6 (4): 685-694.

[14] **Bakry, Kh.A.; M.A. Khamis; M.M. Sharaf; H.K. Ebrahim and H.I. Yassin, (2013)**. Response of Washington navel orange trees to foliar spray with some bio and mineral fertilizers. The first international conference for economic development in African and Arab region, 23-24 April, Ismailia, Egypt

[15] **Bhupinder S. and K. Usha (2003).** Salicylic acid induced physiological and biochemical changes in wheat seedlings under water stress. *Pl. Grow. Regul.*, **39:** 137-141.

[16] B**orsani, O., V. Valpuesta and A. Botella (2001)**. Evidence for a role of salicylic acid in the oxidative damage generated by NaCl and osmotic stress in Arabidopsis seedlings. *Plant Physiology*, **126:** 1024–1030.

[17] **Cao, J., Zeng, K., and Jiang, W. (2006).** Enhancement of postharvest disease resistance in Yali pear *(Pyrus bretschneideri*) fruit by salicylic acid sprays on the trees during fruit growth. Eur. J. Plant Pathol. 114, 363–370.

[18] Champa, W. A. H., Gill, M. I. S., Mahajan, B. V. C., and Arora, N. K. (2015). Preharvest salicylic acid treatments to improve quality and postharvest life of table grapes (Vitis vinifera L.) cv. Flame Seedless. J. Food Sci. Technol. 52,3607–3616. doi: 10.1007/s13197-014-1422-7

[19] **Chini, A., J.J. Grant, M. Seki, K. Shinozaki and G.J. Loake (2004**).Drought tolerance established by enhanced expression of the CCI-NBS-LRR gene, ADR1, requires salicylic acid, EDS1 and ABI1. *The Plant Journal*, **38:** 810–822

[20] **Chokha, S.; S. K. Saxena; A. M. Gaswami; R. R. Sharma and C. Singh (2000).** Effect of fertilizers on growth, yield and quality on sweet orange (*Citrus sinensis*) Cv. Mosambi. Indian Journal of Horticulture, 57 (2): 114-117.

[21] **Clarke, G.M. and R.E. Kempson (1997).** In "Introduction to the Design and Analysis of Experiments". (Arnold Ed.). A Member of the Holder Headline Group, London, UK

[22] **Duncan, D.B. (1955).** Multiple ranges and multiple F Test. Biometrics, 11:1-42.

[23] **El–Geuoshy, S.F., (2011)**. Physiological and an atomical studies on some factors affecting productivity and nutritional status of Navel orange. Ph.D. Thesis., Fac. of Agric. Benha Univ. Egypt.

[24] **El-Hifny, I.M.M. and M.A.M. El-Sayed, (2011**). Response of sweet pepper plant growth and productivity to application of ascorbic acid and biofertilizers under saline conditions. Australian Journal of Basic and Applied Sciences, 5(6): 1273-1283.

[25] **EL-Massriy, M.M.A., (2009)**. Production of lettuce using organic, bio- and mineral fertilization under saline conditions. P.h.D. Thesis. Dep. of Hort., Fac. of Agr. Ain Shams University, Cairo, Egypt

[26] **El-Sibaie, M.F., (1995).** Biomagic, a biological promoter patent by the patent office, Academy of Scentific Research and Technology, Egypt, 5/1995

[27] **Elwan, M.W.M.; M.A.M. El-Hamahmy (2009).** Improved productivity and quality associated with salicylic acid application in greenhouse pepper.SciHortic.122:521–6.

[28] **Freeman, J.L., D. Garcia, D. Kim, A.M. Hopf and D.E. Salt (2005).** Constitutively elevated salicylic acid signals glutathione mediated nickel tolerance in Thlaspi nickel hyper accumulators. *Plant Physiology*, **137:** 1082–1091.

[29] García-Pastor, M. E., Zapata, P. J., Castillo, S., Martínez-Romero, D., Valero, D.,Suneel Sharma1, Manjeet (2020) Heat Stress Effects in Fruit Crops: A Review.Agriculture Reviews,volume 41Issue 1:73-78(March2020)

[30] **Giannousis, K. (2012).** Effects of 1-MCP, Salicylic Acid and Hydrogen Peroxide onFruit Quality Attributes and Storage in Different Apple (Malus pumila Mill.)Cultivars. Ph D. thesis, Aristotle University of Thessaloniki, Thessalon

[31] **Giménez, M. J., Serrano, M., Valverde, J. M., Martínez-Romero, D., Castillo,S., Valero, D., et al. (2017)**. Preharvest salicylic acid and acetylsalicylic acid treatments preserve quality and enhance antioxidant systems during postharvest storage of sweet cherry cultivars. J. Sci. Food Agric. 97, 1220–1228. doi: 10.1002/jsfa.7853

[32] Giménez, M. J., Valverde, J. M., Valero, D., Guillén, F., Martínez-Romero, D., Serrano, M., et al. (2014). Quality and antioxidant properties on sweet cherries as affected by preharvest salicylic and acetylsalicylic acids treatments. Food Chem. 160, 226–232. doi: 10.1016/j.foodchem.2014.03.107

[33] **Hamdy I.M. Ibrahim, Ahmed M. Kamal, Ahmed Akl and Amira A. Ibrahim*(*2019).** Effect of spraying salicylic acid on growth and fruiting of sultani fig trees (*Ficus carica* L.). *Minia J. of Agric. Res. & Develop. Vol. (39), No. 1, pp. 133*-150.

[34] **Hanan A. E. A. Hashem (2016).** Effect of Sowing Date and Fertilization Treatments on Growth and Chemical Constituents of Calendula officinalis Plants under North Sinai conditions. Middle East Journal of Agriculture Research. 5 (4): 761-774

[35] **Hayat, Q.; S. Hayat; M. Irfan; A. Ahmad (2010).** Effect of exogenous salicylic acid under changing environment: a review. Environ Exp Bot 68:14–25.

[36] **Helaly, M. N., El-Sheery, N. I., El-Hoseiny, H., Rastogi, A., Kalaji, H. M., and Zabochnicka-Świątek, M. (2018)**. Impact of treated wastewater and salicylic acid on physiological performance, malformation and yield of two mango cultivars. *Sci. Hortic.* 233, 159–177. doi: 10.1016/j.scienta.2018.01.001

[37] **Holland, D.; Hatib, K. and Bar-Yàakov, I., (2009**). Pomegranate: Botany, horticulture, breeding. Horticultural Reviews 35, 127–191.

[38] **Huang, R., Xia, R., Lu, Y., Hu, L., and Xu, Y. (2008)**. Effect of pre-harvest salicylic acid spray treatment on post-harvest antioxidant in the pulp and peel of 'Cara cara' navel orange (Citrus sinenisis L. Osbeck). J. Sci. Food Agric. 88, 229–236. doi: 10.1002/jsfa.3076

[39] **Ibrahim-Asmaa, A., 2006.** Influence of some biofertilizers and antioxidants on Red Roomy grapevines. (*Vitis vinifera* L.). Ph.D. Thesis., Fac. of Agric. Minia Univ. Egypt.

[40] **Ibrahim, T.M.A., (2009**). Studies on the development and production of globe artichoke (cynara scolymus, L.) under Sinai conditions. M. Sci. Thesis. Fac. of Agric. Al-Azhar Univ. Cairo, Egypt

[41] **Imran, H., Z. Tuxing, D.M. Guogiang, W. Guoying and**

Z. Jianghong, 2007. Effect of Salicylic acid (SA) on delaying fruit senescence of Huang Kum pear. Agric. China., 1(4): 456-459.

[42] **Kang, H.M. and M.E. Saltveit (2002).** Chilling tolerance of maize, cucumber and rice seedling leaves and roots are differentially affected by salicylic acid. *Physiologia Plantarum*, **115:** 571–576.

[43] **Khamis, M. A.; M. M. Sharaf; Kh. A. Bakry and A.S. Abdel- Moty (2014).** Response of Guava Transplants to Some Bio-Fertilizers. Middle East Journal of Agriculture Research, 3(4): 1184 -1188.

[44] **Khan, W., B. Prithiviraj and D.L. Smith (2003).** Photosynthetic response of corn and soybean to foliar application of salicylates. *Journal of Plant Physiology*, **160:** 485-492. http://dx.doi.org/10.1078/0176-1617-00865

[45] **Khedr, Z.M.A. and S. Farid, (2000).** Response of naturally virus infected tomato plants to yeast extract and phosphoric acid application. Annals of Agric. Sci., Moshtohor, 38(2): 927-939.

[46] **Kondo, S. (2006).**The roles of jasmonates in fruit color development and chilling injury. Acta Hortic. 727,45-56

[47] **Koo, Y. M., Heo, A. Y., and Choi, H. W. (2020)**. Salicylic acid as a safe plant protector and growth regulator. Plant Pathol. J. 36, 1–10. doi: 10.5423/PPJ.RW.12.2019.0295

[48] **Larkindale, J., J.D. Hall, M.R. Knight and E. Vierling (2005).** Heat stress phenotypes of Arabidopsis mutants implicate multiple signaling pathways in the acquisition of thermotolerance. Plant Physiology, 138: 882–897

[49] Martínez-Esplá, A., Zapata, P. J., Valero, D., Martínez-Romero, D., Díaz-Mula, H. M., and Serrano, M. (2018). Preharvest treatments with salicylates enhance nutrient and antioxidant compounds in plum at harvest and after storage. J. Sci. Food Agric. 98, 2742–2750. doi: 10.1002/jsfa.8770

[50] **Marzouk, H.A.; HA. Kassem (2011).** Improving yield, quality, and shelf life of Thompson seedless grapevine by preharvest foliar applications.Sci Hortic . 130 :425 –430.

[51] Mirdehghan, S.H. G. Vatanparast, H.R. Karimi and M.H. Vazifeshenas (2012). Preharvest foliar application of methyl jasmonate, salicylic acid and potassium sulfate on improving the quality of pomegranate fruit *Options Méditerranéennes, A, no. 103, 2012*

[52] **Mokhtar M. Shaaban, Ahmed. M.K. Abd El-Aal and Faissal F. Ahmed (2011)** Insight into the Effect of Salicylic Acid on Apple Trees Growing under Sandy Saline Soil Research Journal of Agriculture and Biological Sciences, 7(2): 150-156, 2011

[53] **Oraei, M., Panahirad, S., Zaare-Nahandi, F., and Gohari, G. (2019)**. Pre-véraisontreatment of salicylic acid to enhance anthocyanin content of grape (Vitis vinifera L.) berries. J. Sci. Food Agric. 99, 5946–5952. doi: 10.1002/jsfa.9869

[54] **Osman, S. M.; M. A. Khamis and A. M. Thorya (2010).** Effect of mineral and Bio-NPK Soil application on vegetative growth, flowering, fruiting and leaf chemical composition of young olive trees. Research Journal of Agriculture and Biological Sciences, 6 (1): 54-63.

[55] **Rivas-San Vicente, M., and Plasencia, J. (2011**). Salicylic acid beyond defence: its role in plant growth and development. J. Exp. Bot. 62, 3321–3338.

[56] **Saber, S. M. (1993).** The use of multi-strain bio-fertilizer in agriculture. Theory and pratice. Proc. Sixth International Symposium on Nitrogen Fixation with Non-legumes, Ismailia, Egypt, p.61.

[57] **Senarataa, T., Touchell, D., Bunn, E. and Dixon, K., (2004).** Acetyle salicylic acid (Aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Growth Refulator 30:157-161.

[58] **Shaaban, M. M., Abd El-Aal, A. M. K., and Ahmed, F. F. (2011**). Insight into the effect of salicylic acid on apple trees growing under sandy saline soil. Res. J.Agric. Biol. Sci. 7, 150–156.

[59] **Shaban, A.E.A. and A.T. Mohsen, (2009)**. Response of citrus rootstock and transplants to bio-fertilizers. Journal of Horticultural Science & Ornamental Plants, 1(2): 39-48.

[60] **Shakirova, F. M. (2007).** Role of hormonal system in the man is festation of growth promoting and anti-stress action of salicylic acid. In S. Hayat and A. Ahmad (Eds), *Salicylic acid. A plant hormone*. Dordrecht, Netherlands: Springer

[61] **Sheren A. A. El Hamied (2014a**) Improving Growth and Productivity of "Sukkary" Mango Trees Grown in North Sinai Using Extracts of Some Brown Marine Algae, Yeasts and Effective Microorganisms 1-Mineral content of leaves and fruit growth aspects Middle East Journal of Agriculture Research, 3(2): 318-329, 2014

[62] **Sheren A. A. El Hamied (2014b**) Improving Growth and Productivity of "Sukkary" Mango Trees Grown in North Sinai Using Extracts of Some Brown Marine Algae, Yeasts and Effective Microorganisms 2- Productivity and fruit quality Middle East Journal of Applied Sciences 4(3): 460-470, 2014

[63] **Sheren A. Abd El-Hamied (2019)** Improvement of fig growth and productivity at Siwa Oasis j. Biol. chem. Environ Sci.14 (1): 59-87

[64] **Simaei, M., R.A. Khavari-Nejad and F. Bernard (2012)**.Exogenous application of salicylic acid and nitric oxide on the ionic contents and enzymatic activities in NaCl stressed soybean plants. *Amer. J. Plant Sci.*, **3:** 1495-1503.

[65] **Soliman, M.G., (2001)**. Response of banana and guava plants to some biological and mineral fertilizers. M.Sc. Thesis, Fac. of Agric. Alex. Univ. Egypt.1144 – 1151.

[66] Stover, E. and E.W. Mercure (2007). The pomegranate: A new look at the fruit of paradise. HortScience, 42: 1088-1092

[67] **Stuart Y. Jansma, Lidiya I. Sergeeva, Yury M. Tikunov, Wouter Kohlen,Wilco Ligterink and Ivo Rieu (2022**). Low Salicylic Acid Level Improves Pollen Development Under Long-Term Mild Heat Conditions in Tomato. Frontiers in Plant Science April 2022 | Volume 13 | Article 828743.

[68] **Suman, M., Sangma, P.D., and Singh, D. (2017)** 'Role of Micronutrients (Fe, Zn, B, Cu, Mg, Mn and Mo) in Fruit Crops', *Int. J. Curr. Microbiol. App. Sci.*, 6(6), pp. 3240-3250. doi:10.20546/ijcmas.2017.606.382

[69] Valverde, J. M., Giménez, M. J., Guillén, F., Valero, D., Martínez-Romero, D., and Serrano, M. (2015). Methyl salicylate treatments of sweet cherry trees increase

antioxidant systems in fruit at harvest and during storage. Postharvest Biol. Technol. 109, 106–113. doi: 10.1016/j.postharvbio.2015.06.011

[70] **War, A.R., Paulraj, M.G., Ahmad, T., Buhroo, A.A.,Hussain, B., Ignacimuthu, S. and Sharma, H.C. (2012).** Mechanisms of plant defense against insect herbivores. *Plant Signal Behav*, 7(10): 1306-1320.

[71] **Yao, H., and Tian, S. (2005).** Effects of pre- and post-harvest application of salicylic acid or methyl jasmonate on inducing disease resistance of sweet cherry fruit in storage. Postharvest Biol. Technol. 35, 253–262. doi: 10.1016/j.postharvbio.2004.09.001

[72] **Ying-Ning Zou, Chun-Yan Liu, Qiang-Sheng Wu (2014).** Regulated effects of exogenous salicylic acid on flower dropping and fruit setting of *Citrus unshiu* . BCAIJ, 8(4), 2014 [111-114].

[73] **Yordanova, R. and L. Popova (2007).** Effect of exogenous treatment with salicylic acid on photosynthesis activity and antioxidant capacity of chilled wheat. *Gen. Appl. Plant Physiol.*, **33:** (3-4)155–170

[74] **Zhang, Y., Chen, K., Zhang, S., and Ferguson, I. (2003).** The role of salicylic acid in postharvest ripening of kiwifruit. *Postharvest Biology and Technology*, *28*(1), 67–74.